

## 2D Materials - Graphene Activity

Overview: In this activity students attempt to isolate a one-atom thick layer of graphite (graphene) through manual exfoliation, using a method that won a Nobel prize in 2010.

### Materials:

- [Nobel Prize Press Release](#) (below)
- Graphite samples
- Clear scotch tape
- A pencil
- White paper
- Digital microscope
- Structure of Graphene image (below)
- One- dimensional materials images
- Graphene under the microscope image
- [Graphene Film](https://vimeo.com/1051348536/0294b34d3d?share=copy) (<https://vimeo.com/1051348536/0294b34d3d?share=copy>)

### Preparation

Watch the [Graphene Film](#) prior to students arriving for the activity.

### Directions:

1. Explain to students that they have the opportunity to participate in an experiment that won a Nobel prize in 2010. Show them the Nobel Prize press release.
2. Each student will need a long strip of tape and access to a piece of graphite.
3. Give students time to take turns pressing their tape onto the graphite, pressing or rubbing it firmly, and peeling it off.
4. Alternatively, some students could sample graphite from a sheet of paper with shading from a pencil to compare (use the side of a pencil to darken an area on paper, then use tape to carefully peel some of the graphite off).
5. Students should then fold the tape back onto itself and pull it apart several times (further separating graphite layers). This step is clearly demonstrated in the video. Instead of transferring the graphene to a silicon wafer, instead stick the tape to a piece of white paper.
6. Using a digital microscope, view the thin layers of graphite. Layers will likely still appear dark. Single atom layers of graphene are transparent, so not visible using a light microscope and a glass slide. To be able to view a single atom layer, you will need a darker substrate (such as a silicon wafer).

7. See if you can identify a single layer – graphene. It can be difficult to see – use the demonstration on the Graphene Film (at 3:30) and/or the provided images for reference, and to show how graphene really appears (which will be different than what is seen through the handheld microscope).
8. Play the Graphene Film video for students (optional – could be shown before or after the activity).

### Explaining the science:

Graphene is the name of a one atom thick sheet of the material graphite. Graphite is the material commonly used as pencil “lead”. Researchers, Andre Geim and Konstantin Novoselov, who successfully exfoliated graphene from graphite, won the Nobel Prize in Physics in 2010. See the [Nobel Prize press release](#) below.

As you will experience through this activity, mechanical exfoliation is a fairly simple process using simple tools (like tape). It works because of the atomic structure of graphite is similar to a stack of paper – where sheets peel off but when pulled apart, the sheet itself is very strong and flexible.

### Standard Alignment

Standard Code	Standard Text	How does this activity support this standard?

This resource was provided by the MSU Science Math Resource Center using resources from the MSU Applied Quantum CORE funded by the Air Force Office of Scientific Research to accompany [Graphene Film](#) by MSU School of Film & Photography. 412 Reid Hall • [smrc@montana.edu](mailto:smrc@montana.edu)

## The Nobel Prize in Physics 2010

The Royal Swedish Academy of Sciences has decided to award the Nobel Prize in Physics for 2010 to

**Andre Geim**

University of Manchester, UK

and

**Konstantin Novoselov**

University of Manchester, UK

*“for groundbreaking experiments regarding the two-dimensional material graphene”*

### Graphene – the perfect atomic lattice

A thin flake of ordinary carbon, just one atom thick, lies behind this year's Nobel Prize in Physics.

Andre Geim and Konstantin Novoselov have shown that carbon in such a flat form has exceptional properties that originate from the remarkable world of quantum physics.

Graphene is a form of carbon. As a material it is completely new – not only the thinnest ever but also the strongest. As a conductor of electricity it performs as well as copper. As a conductor of heat it outperforms all other known materials. It is almost completely transparent, yet so dense that not even helium, the smallest gas atom, can pass through it. Carbon, the basis of all known life on earth, has surprised us once again.

Geim and Novoselov extracted the graphene from a piece of graphite such as is found in ordinary pencils. Using regular adhesive tape they managed to obtain a flake of carbon with a thickness of just one atom. This at a time when many believed it was impossible for such thin crystalline materials to be stable.

However, with graphene, physicists can now study a new class of two-dimensional materials with unique properties. Graphene makes experiments possible that give new twists to the phenomena in quantum physics. Also a vast variety of practical applications now appear possible including the creation of new materials and the manufacture of innovative electronics. Graphene transistors are predicted to be substantially faster than today's silicon transistors and result in more efficient computers.

Since it is practically transparent and a good conductor, graphene is suitable for producing transparent touch screens, light panels, and maybe even solar cells.

When mixed into plastics, graphene can turn them into conductors of electricity while making them more heat resistant and mechanically robust. This resilience can be utilised in new super strong materials, which are also thin, elastic and lightweight. In the future, satellites, airplanes, and cars could be manufactured out of the new composite materials.

This year's Laureates have been working together for a long time now. Konstantin Novoselov, 36, first worked with Andre Geim, 51, as a PhD-student in the Netherlands. He subsequently followed Geim to the United Kingdom. Both of them originally studied and began their careers as physicists in Russia. Now they are both professors at the University of Manchester.

Playfulness is one of their hallmarks, one always learns something in the process and, who knows, you may even hit the jackpot. Like now when they, with graphene, write themselves into the annals of science.

**Andre Geim**, Dutch citizen. Born 1958 in Sochi, Russia. Ph.D. 1987 from Institute of Solid State Physics, Russian Academy of Sciences, Chernogolovka, Russia. Director of Manchester Centre for Mesoscience & Nanotechnology, Langworthy Professor of Physics and Royal Society 2010 Anniversary Research Professor, University of Manchester, UK.

[www.condmat.physics.manchester.ac.uk/people/academic/geim](http://www.condmat.physics.manchester.ac.uk/people/academic/geim)

**Konstantin Novoselov**, British and Russian citizen. Born 1974 in Nizhny Tagil, Russia. Ph.D. 2004 from Radboud University Nijmegen, The Netherlands. Professor and Royal Society Research Fellow, University of Manchester, UK.

[www.condmat.physics.manchester.ac.uk/people/academic/novoselov](http://www.condmat.physics.manchester.ac.uk/people/academic/novoselov)

**Prize amount:** SEK 10 million to be shared equally between the Laureates.

**Further information:** <http://kva.se> and <http://nobelprize.org>

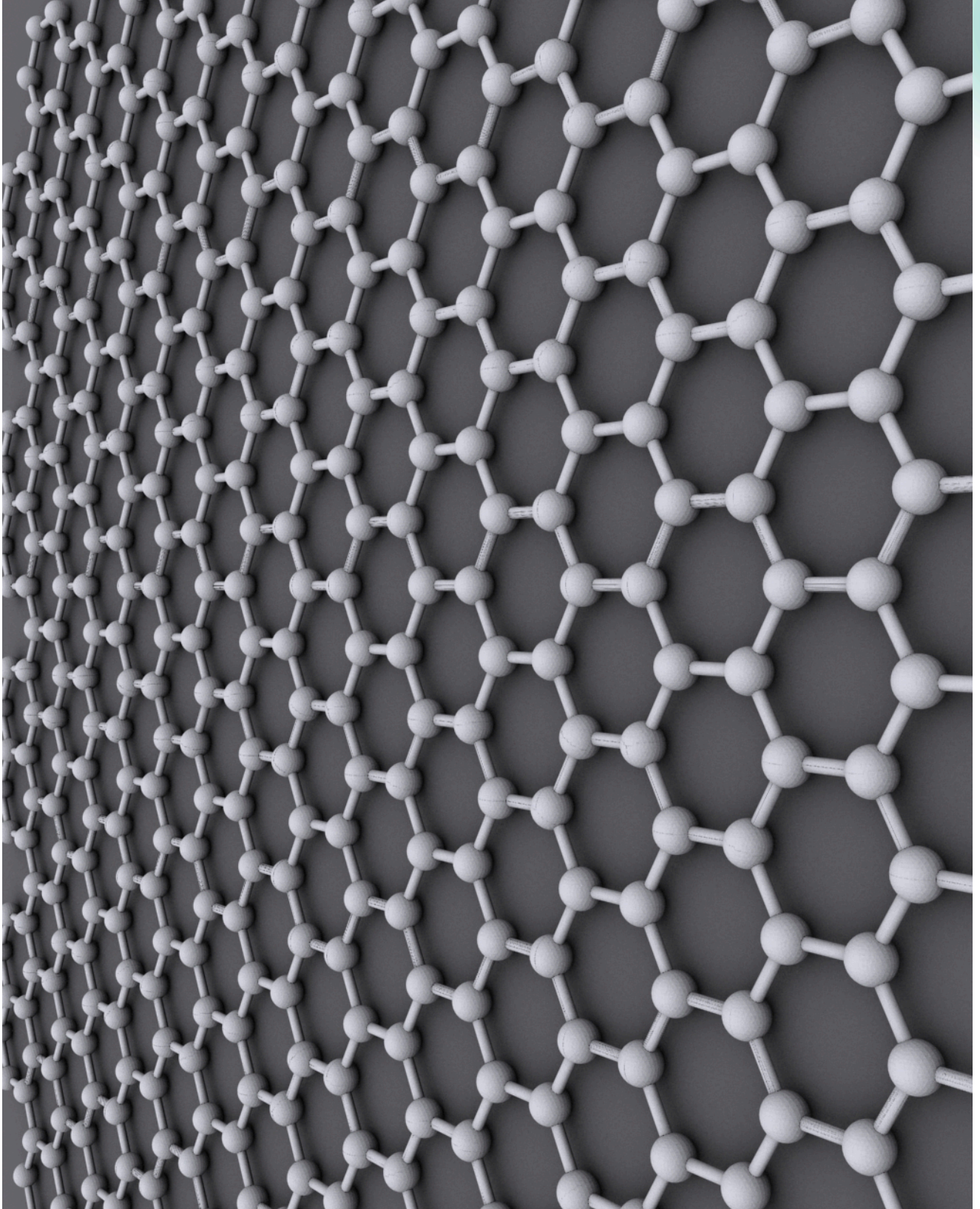
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The Royal Swedish Academy of Sciences, founded in 1739, is an independent organization whose overall objective is to promote the sciences and strengthen their influence in society. The Academy takes special responsibility for the natural sciences and mathematics, but endeavours to promote the exchange of ideas between various disciplines.

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<https://www.nobelprize.org/prizes/physics/2010/press-release/>

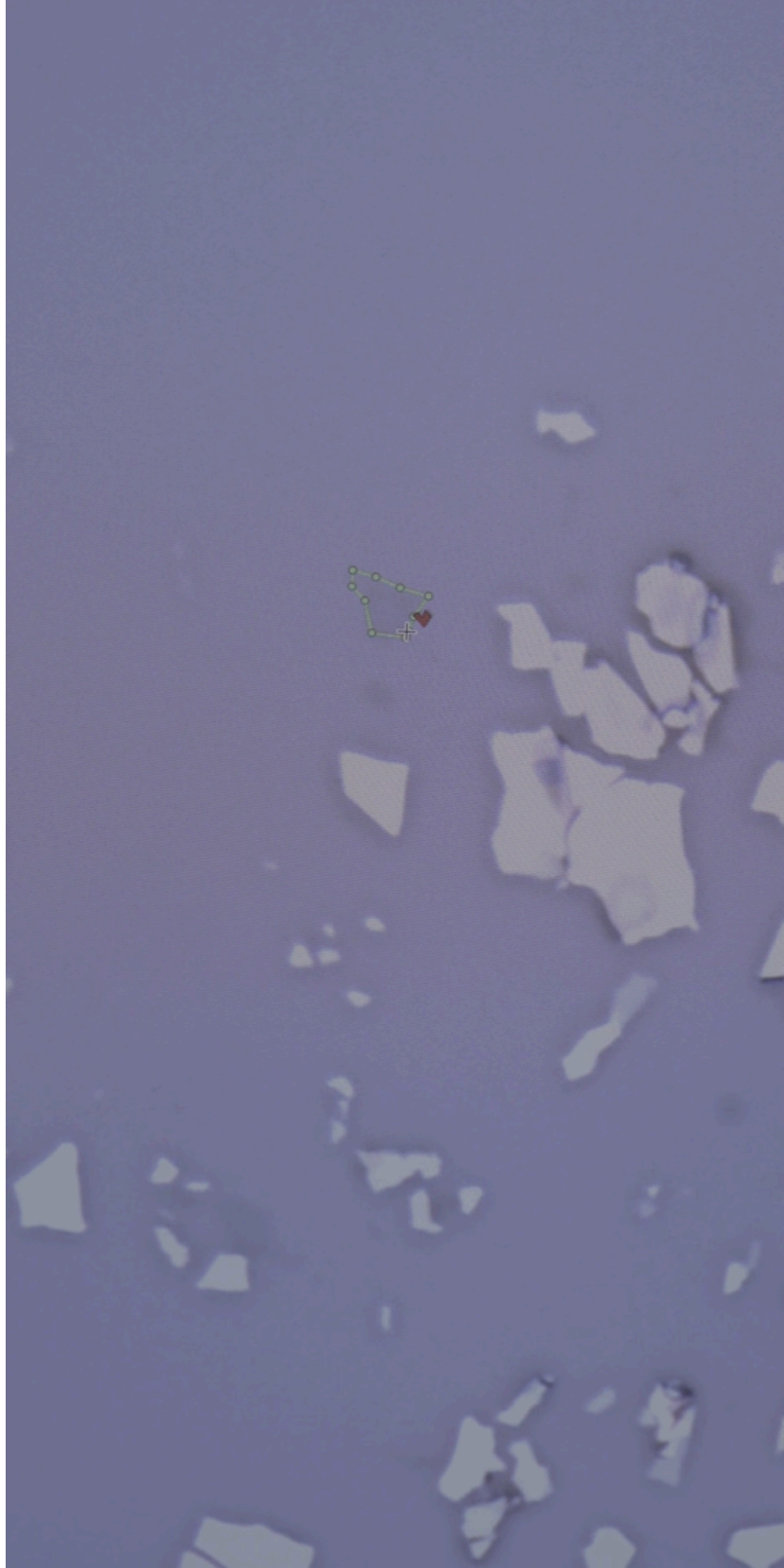


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Screenshot from Graphene Film, 3:35

Properties	Graphene	Graphite
Surface Area	Extremely high	Comparatively low
Appearance	Transparent and colorless	Opaque and black/gray
Strength	Strongest material known to exist	Brittle
Conductivity	Exceptionally electrically and thermally conductive	Relatively good conductivity but not as good as graphene
Applications	Electronics, energy storage, sensors	Pencils, lubricants, batteries

Condensed from: <https://www.ossila.com/pages/graphene-vs-graphite>